ROYAL ASTRONOMICAL SOCIETY.

VOL. XVII. *March* 13, 1857. No. 5.

REV. BADEN POWELL, V.P., in the Chair.

James Simms, Esq., Carshalton;
W. J. Gillett, Esq., Harley Street; and
Capt. R. Fitzroy, R.N.;

were balloted for and duly elected Fellows of the Society.

For notice of two new comets, see page 161.

Results of the Observations of Small Planets made at the Royal Observatory, Greenwich, in the Months of January and February, 1857.

(*Communicated by the Astronomer Royal.*)

Amphitrite.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ′ ″
1857, Jan. 2 8 38 12·58	3 27 54·07	61 52 5·31
16 7 44 42·73	3 29 27·26	62 25 49·13
19 7 34 4·23	3 30 36·68	62 30 31·60
23 7 20 18·75	3 32 35·17	62 35 26·00

Hebe.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ′ ″
1857, Feb. 16 11 57 57·46	9 45 36·84	73 38 22·44
23 11 24 8·56	9 39 18·27	72 32 0·08
24 11 19 21·08	9 38 26·57	72 23 1·04
26 11 9 48·49	9 36 45·52	72 5 31·12

Parthenope.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ′ ″
1857, Jan. 31 14 3 34·13	10 48 29·25	79 14 32·27
Feb. 16 12 48 21·71	10 36 9·38	77 28 14·41
24 12 9 40·27	10 28 54·02	76 32 40·11
26 11 59 58·41	10 27 3·67	76 19 9·74
28 11 50 16·96	10 25 13·75	76 6 0·06

Lutetia.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ′ ″
1857, Jan. 19 8 12(30)	.....	68 45 51·19
Feb. 14 6 40 47·98	4 19 42·14	67 59 15·60

There is some doubt whether the above places are those of *Lutetia*.

Fides.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ′ ″
1857, Jan. 27 14 46 21·55	11 15 37·48	82 16 40·23
Feb. 16 13 14 15·20	11 2 7·12	81 3 2·06
24 12 35 38·04	10 54 56·05	80 26 37·02
26 12 25 54·71	10 53 4·23	80 17 24·28

The Occultations of Jupiter and his Satellites on the 2d of January, as observed at the Cambridge Observatory. By Professor Challis.

"I delayed sending to the Astronomical Society my observations of the occultation of *Jupiter*, till I could complete certain calculations founded upon them, which proved to be long and intricate. The results of the calculations are added to the following account of the observations.

"Expecting a good opportunity, I made every requisite preparation for observing the occultations with the Northumberland equatorial. My junior assistant, Mr. Taylor, counted from a chronometer, and recorded the times; so that, while observing

the times of immersion and emersion, I was at liberty to notice physical phenomena. The magnifying power employed was 215. Mr. Breen observed, by himself, with the 5-feet equatorial, using a power of 120. The following are the Greenwich mean times of the occurrences, as deduced from the noted times of the two observers. The letters C and B indicate the observers.

Greenwich Mean Times of Disappearances.

	C	B	
	h m s	s	
Satellite IV.	4 45 31·46	31·60	(*a*)
— III.	4 53 2·47	3·47	(*b*)
Jupiter, beginning	4 59 47·98	50·35	(*c*)
— end	5 1 27·18	27·19	(*d*)
Satellite I.	5 2 16·48	16·85	(*e*)
— II.	5 3 29·05	27·98	(*f*)

Greenwich Mean Times of Reappearances.

	C	B	
	h m s	s	
Satellite IV.	5 38 32·54	...	(*g*)
— III.	5 49 52·55[1]	32·20	(*h*)
Jupiter, beginning	5 59 13·57	18·40	(*i*)
— , end	6 0 44·77	44·56	(*k*)
Satellite I.	6 1 57·07	71·91	(*l*)
— II.	6 3 40·57	58·33	(*m*)

"The following are the notes which I made in the observing-room immediately after the respective observations:—

"'(*a*) The satellite disappeared gradually: the time noted is the mean between the beginning and end of obscuration, which occupied about $1\frac{1}{2}^{s}$. (*b*) Gradually, as before. It first appeared cut off a second earlier: the time noted is that of bisection of the satellite by the moon's limb. (*c*) The time of first contact, perhaps, a little late: half a second after the recorded time the limb was quite perceptibly cut off. (*d*) This time is very exact. (*e*) Time of bisection: disappeared rather more suddenly than the two preceding. (*f*) Occupied in disappearing about the same time as satellite I.

"'During the occultation of *Jupiter* I noticed particularly the form of his disk. I could not perceive any elongation of the line of section by the moon's limb, the contour of *Jupiter* appearing continually round. I lost the impression of his oblateness. The moon's limb was faintly visible. When *Jupiter* was about half cut off, I remarked that the section was rather jagged, and in particular that there was a bright projection at about the middle point.

"'(*g*) First seen at this time, when it was about 4″·5 from

[1] An error of 20ˢ in recording.

the limb. (*h*) First seen at 2″ from the limb. (*i*) Time rather late: the limb projected perhaps 2″·5. (*k*) This is exact. (*l*) 2″ from the limb. (*m*) Good: the satellite seen adhering to the limb.

"'I thought *Jupiter*, at reappearance, seemed flattened towards the moon's limb. My attention was a good deal directed to a faintish shadow running along the moon's limb, and of about 4″ in breadth. This continued during the whole of the reappearance. Just at the total emergence the point of contact was obscure, and seemed to recede from the moon's limb. Perhaps the noted time of complete emergence may, on this account, be a little too early. The emergence took place at a depression of the moon's limb, extending beyond *Jupiter* on both sides. This was very conspicuous. The moon's irradiation appeared cut off at this part.'

"Mr. Breen noted as follows:—

"'Times of disappearing beautifully exact. The satellites were about $1\frac{1}{2}^s$ in disappearing. Circumstances very favourable. No perceptible distortion in the form of *Jupiter:* its oblate shape very noticeable during the time of its disappearance.

"'The observations of reappearance satisfactory, but those of the satellites not as good as the observations of disappearances. They appeared *instantaneously.* During the time of emersion *Jupiter* seemed indented into the moon's limb. No distortion of its shape was noticed.'

"To the foregoing rough notes I beg to add a few remarks. The atmospheric circumstances of the observations were particularly good; both *Jupiter* and the moon's limb appearing at times with extraordinary definition. This was remarkably the case at *Jupiter's* emergence, the moon's limb during the whole time and after being quite sharp and free from irradiation. The planet, when fairly separated, was strikingly beautiful: its contour and belts were steady and distinct: being visibly brighter at the central part of the disk than towards the border, it had something of a pellucid appearance: its light was pale compared to that of the moon, and had the slightest possible tinge of olive green. The most remarkable phenomenon was the dark fringe bordering the moon's limb: it was darker than *Jupiter's* belts; and continuing to the end of the emersion, made the observation of last contact somewhat difficult. This circumstance seems to prove that the fringe could not be the mere effect of contrast between the moon's light and that of *Jupiter.* Describing it after the observation, I said it reminded me of *Saturn's* dusky ring. The bright projection noticed at the immersion was due to an indent in the moon's limb, and its brightness was probably remarked in consequence of its being situated between the two principal belts. This observation seems to show that no such phenomenon as the dark fringe occurred at the immersion. Can this phenomenon be connected in any way with the circumstance that the emersion took place at a depressed part of the moon's limb? I made an attempt to measure

the depth of the depression when the moon was of the same age in the next lunation, and obtained, with some uncertainty, 1″·8, the state of the atmosphere not being favourable. I have no reason to conclude that the form of *Jupiter* suffered distortion either at immersion or emersion, the flattened appearance which I noticed at emersion being probably only the oblateness.

"The estimations of the distances of the objects from the moon's limb when first seen on reappearance, were made by means of the known interval between the teeth of the micrometer-comb. This method of estimation was subsequently verified by first estimating and then reading off intervals between the micrometer wires. The emersion of the 4th satellite was seen late from my not being prepared for it, and not knowing exactly where to look. I can hardly account for not seeing the 3d and 1st satellites and *Jupiter's* 1st limb earlier, as they were looked for in the right places. They seemed to come into view suddenly. Mr. Breen's times of emersion of the 1st and 2d satellites were proved by calculation to be much too late.

Calculation, from the foregoing Observations, of the Positions of the Satellites relative to Jupiter's Centre.

"Let p be the difference of apparent R.A., estimated on the arc of a great circle, and q the difference of apparent N.P.D. of *Jupiter's* centre, or a satellite, and the moon's centre, at the noted time of immersion, and $p + \alpha$, $q + \beta$, the same for that of emersion. Then, S being the moon's apparent semidiameter at the first time, and S + ε the apparent semidiameter at the second time, inclusive of estimated distance from the moon's limb, we shall have very nearly—

$$p^2 + q^2 = \mathrm{S}^2 \text{ and } (p + \alpha)^2 + (q + \beta)^2 = (\mathrm{S} + \varepsilon)^2.$$

"Consequently if $\frac{q}{p} = \tan \varphi$ and $\frac{\beta}{\alpha} = \tan \theta$, the following equations determine φ, p and q:

$$\cos(\varphi - \theta) = -\frac{\alpha}{2\,\mathrm{S}\cos\theta} + \frac{\varepsilon\cos\theta}{\alpha}\left(1 + \frac{\varepsilon}{2\,\mathrm{S}}\right)$$

$$p = \mathrm{S}\cos\varphi, \qquad q = \mathrm{S}\sin\varphi.$$

"To effect the calculations by these formulæ, the differences of the apparent R.A. and N.P.D. of the moon and *Jupiter*, and the moon's apparent semidiameter, at 4^h, 5^h, 6^h, and 7^h, were first calculated from the tables: whence α, β, and S, were inferred by interpolation to second or third differences. The calculations having been gone through for the times of immersion and emersion of *Jupiter's* centre, the resulting values of p and q showed that the tabular excess of the moon's apparent R.A. above that of *Jupiter* required the correction − 5″·48, and the tabular excess of apparent N.P.D. the correction + 7″·30.

"To find α and β for a satellite, it was necessary to take account

of the satellite's motion in R.A. and N.P.D. between the immersion and emersion. This was done by means of the data for calculating the co-ordinates x and y relative to *Jupiter*, which are given for each satellite in the Berlin Ephemeris. The direction of the axis of x was first assumed approximately, and the error of the assumption then corrected by the result of the calculation. The differences of the R.A. and N.P.D. of the moon and satellite were then deduced from the above formulæ for the time of immersion, and the corrected differences of R.A. and N.P.D. of the moon and *Jupiter* for the same time being known, those of *Jupiter* and the satellite were immediately inferred. The following are the principal results of the calculations:—

Greenwich M.T.	Satellite.	Jupiter — Satellite, R.A.	Jupiter — Satellite, N.P.D.	Distance from Jupiter by Observation.	Tabular Distance.	Excess of Observation.
h m s		″	″	″	″	″
5 2 16·7	I.	+ 57·07	− 20·59	60·67	57·00	+ 3·67
5 3 28·5	II.	+ 94·29	− 36·61	101·08	92·22	+ 8·86
4 53 2·5	III.	−220·04	+ 111·04	246·47	240·94	+ 5·53
4 45 31·5	IV.	−458·35	+ 221·02	508·86	502·55	+ 6·31

"These results depend on the assumed values of the semidiameters of the moon and *Jupiter*, which were taken without alteration from the *Nautical Almanac*. *Jupiter's* equatorial diameter, as inferred from the interval occupied by the immersion, the form of the disk being taken into account, is found to be 19″·14, which probably should be increased by a small fraction of a second, it being scarcely possible by this kind of observation to obtain the full amount of the diameter. The value inferred from the duration of the emersion, and corrected by + 1″·25 for the estimated distance of *Jupiter's* first limb from the moon, is 18″·43. The assumed tabular value is 19″·59. It would thus appear that the assumed semidiameter is at least not too small, and consequently that the above excesses of observation indicate that the ratios of the mean distances of the satellites to *Jupiter's* equatorial semidiameter, as given in the Berlin Ephemeris, require some correction. No attempt has been made to take into account the effect of the depression of the moon's limb at the place of emergence."

Mr. R. C. May, of No. 4 Sloane Terrace, also witnessed the dark shadow on the disk of *Jupiter*, seen by so many other observers. He forwarded a very well-executed drawing, almost identical with those of Mr. Lassell and the Messrs. Simms, in our previously published accounts. The telescope used by Mr. May was a Newtonian of 6 feet focus, and 6·9 inches aperture, made by himself. The magnifying power employed was not stated.

Mr. James Nasmyth, in a letter to Mr. De la Rue, states that he observed the occultation of *Jupiter*, on Jan. 2, very favourably at Doncaster with one of his 10-inch metals, and a power of 150. He watched anxiously for any indications of a lunar atmosphere, and noticed that at the immersion, instead of any decrease of the brightness of the disk at the time of intersection, there was *visibly* more light there, and at the emersion a dark shadow in contiguity to the bright limb of the moon. Both of these appearances Mr. Nasmyth, no doubt correctly, attributes to the usual effect of contrast. He saw no symptoms of distortion.

Note on the Lunar Occultation of 27 Arietis, on 1857, Feb. 28; observed at Haddenham, Bucks. By the Rev. W. R. Dawes.

"The lunar occultation of 27 *Arietis*, a star of the sixth magnitude, as seen from this place on the 28th of February last, afforded a fine opportunity of watching the effect of an extremely oblique approach of the moon's obscure limb, which was within a few seconds of the star for more than a minute. The 8-inch equatoreal refractor in my observatory having been directed to the star with a power of 172, I carefully noted the appearance of its disk for about ten minutes before the occultation, that my eye might become familiar with the variations of its appearance produced by the condition of our atmosphere. These, however, were not great, the air being generally in a very favourable state, with only occasional and very transient fits of indistinctness. The disk of the star was very sharply defined and steady. To assist my eye in judging of any extraordinary change in its apparent place, I brought it to one of the angles formed by two thick spider's webs crossing in the centre of the field, and within a distance from them of about two of its own diameters; keeping it there by the equable motion of the driving-clock. The moon's obscure limb was distinctly visible. Not the slightest change took place in the star's position, or brightness, or steadiness, or sharpness of definition, while in close proximity to the moon; and at length it disappeared instantaneously and without any warning whatever.

"In my account of the lunar occultation of *Jupiter* in January last, I mentioned a bluish fringe attached to the moon's bright limb, and visible at the reappearance of the planet across its disk. This, from its colour, I attributed to the secondary spectrum of the object-glass. A similar dark fringe was noticed also by Mr. Simms on the same occasion; and, though the colour is not mentioned, this might also be attributed to the same cause. But, as the same phenomenon, so far as its darkness is concerned, was also seen by Mr. Lassell, who observed with his large reflector, some other cause must have contributed in a great degree to produce it; and it has occurred to me, that the shading, apart from

the colour, might be simply the effect of the great contrast between the brilliancy of the moon's limb and the comparative paleness of the planet. The phenomenon may be imitated artificially by placing a white disk close behind the edge of a bright flame; when a very narrow shading, as if with pencil, darkest close to the flame, and rapidly becoming lighter, will appear across the disk.

"It seems to be obviously impossible that the cause of the dark line on the planet should be any atmospheric or other substance attached to the moon. No appearance of the kind was seen at *Jupiter's* occultation at the dark limb; the disk being uniformly bright up to the very edge of the moon, the minutest inequalities of which were plainly visible and sharply defined. Yet it is especially, and perhaps only, at the dark edge that any such effect of a lunar atmosphere might be expected to be discernible: for at the bright edge the atmosphere would itself be highly illuminated; and, therefore, though if of considerable density it might impair the clear definition of the edges and belts of *Jupiter*, it is difficult to conceive how it could appear upon its disk as a dark shading.—The unaltered brightness of very small stars occulted at the dark edge of the young moon, or during a total lunar eclipse, would seem also conclusively to prove that there can exist no atmospheric envelope capable of producing any effects visible to us."

Haddenham, Bucks, 1857, March 11.

Mr. Hippisley, of Ston Easton, near Bath, in a paper which we had not space to notice before, relates an experiment which he lately performed for his own satisfaction, illustrative of the projection of stars on the disk of the moon. He formed an artificial star with a candle placed at a distance of about 185 yards, and an artificial moon with a disk of card attached to a rod applied to the end of his telescope. Illuminating his artificial moon, he was able to make the relative brightnesses of the artificial moon and star nearly in the proportion of nature, and to make the appulse as gradual as he pleased. He thus had an opportunity, he says, of witnessing the overlapping of the two images at leisure, and of convincing himself of the sufficiency of optical considerations for the explanation of what he saw.

On the same subject, but referring more especially to Captain Jacob's note published in page 17 of the current volume, Mr. Lassell mentions an occultation of *Aldebaran*, as far back as the 22d of August 1829, in which he witnessed a distinct entry of the star on to the moon's disk. In the extract of his diary, which was

forwarded, it is related that the star progressed steadily till the moment when it was just wholly within the lunar edge, and then vanished instantaneously. Mr. Lassell remarks, that a star being an indivisible point, and its apparent disk spurious, we might expect to see one-half of the disk thus overlapping the moon's, and that the perplexity felt in seeking an explanation attaches rather to the outer half-disk.

The Astronomer Royal, regarding the reality of the phenomenon as thoroughly established by the concurrent testimony of many able observers, calls attention to the circumstance of its being most frequently and strikingly exhibited in the case of *Aldebaran* and the red stars. He suggests that all occultations of *Aldebaran* should be carefully tabulated, with accounts of the circumstances of the observations, and divided into two classes, one in which the star was situated above the centre of the moon, and the other in which it was below, and that the difference of refraction of the white and red rays should be well weighed as a possible contributing cause.

On Optical Phenomena in Occultations. By the Rev. Baden Powell, M.A., F.R.S., F.R.A.S., Savilian Professor of Geometry in the University of Oxford.

"The singular optical appearances so often witnessed in occultations and allied phenomena, have been ascribed (as is well known) to several causes, (1.) instrumental, or properly optical; (2.) ocular, or personal; (3.) atmospheric, whether lunar, planetary, or terrestrial; or to some combinations of these.

"So far as causes *properly optical* are concerned, I have examined the recorded observations in all the recent cases, with a view to obtain, if possible, some data, especially as referring to the hypothesis of 'irradiation,' or 'diffraction of the object-glass.' In this case, as I have pointed out in a paper in the *Memoirs* of this Society,[1] the essential element *in theory* is the *ratio of the aperture to the focal length* of the telescope employed; the diffraction increasing with the *relative* diminution of the aperture; though, *cæteris paribus*, the effect will be increased by greater *absolute* aperture (*i. e.* more light), and diminished by higher power, *i. e.* diminished intensity of light.

"As on a former parallel occasion,[2] so in reference to recent instances, I have collected, in the annexed tabular view, the data belonging to the several instruments employed; which have been in many instances kindly furnished by the respective observers, beyond the particulars given in the *Notices*.

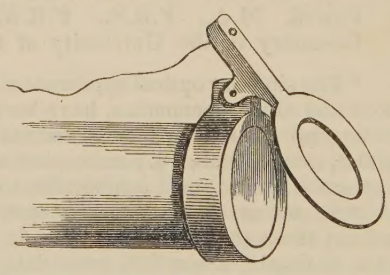
[1] Astronomical Society's *Memoirs*, Vol. xviii. p. 69.
[2] Astronomical Society's *Memoirs*, Vol. xxi. pt. I. p. 116.

"The several cases are arranged in the order of the magnitudes of the *ratio of aperture to focal length.*

"Under the head of 'Phenomena' I have merely designated in the briefest terms possible those appearances described, which seem likely to have any optical relations; presuming the accounts in the *Notices* to be known to the reader. I may add that Mr. Peto, in a letter to me, speaks of the projection which he witnessed as of the limb of *Jupiter indenting* that of the moon, and marked by the dark border observed in so many other cases. He gives a sketch, which seems exactly to agree with the appearance noticed by Professor Challis, which he ascribes to the emergence taking place at a part of the moon's limb where there was a depression. This description might consist with a projection as supposed by Mr. Peto.

"The peculiar halo of light after the disappearance of the satellite noticed by Mr. Brodie, and also, as he informs me, by a friend using the telescope formerly Dr. Pearson's,—as well as the light appearing on the moon at, or after, the immersion of the planet, noticed by several observers—though ascribed by some to a lunar atmosphere—seem to me phenomena apparently allied to those I have formerly adverted to,[1] occasioned by a divergence of light.

"For instantaneously applying or removing a contracted aperture to or from the object-glass, I have found very effective the simple contrivance represented in the annexed sketch, which requires no description, and is effected by merely pulling the string. Several diaphragms with different apertures might be applied over each other in the same way. I made a rough trial of this method in the late occultation, making several alternations during the immersion: but saw no change. Perhaps, however, the loss of light was too great.



Occultation of Jupiter by the Moon, January 2, 1857.

(*See Astronomical Society's Notices*, vol. xvii. No. 3.)

Observer.	Focal Length = F.	Aperture = A.	Ratio $\frac{A}{F}$	Power.	Phenomena.
Baxendell (Newtonian)	ft. in. 9 0	in. 13·0	$\frac{1}{8{\cdot}3}$	...	Imm., light on ♃.
Hippisley (Newtonian)	7 4	9·25	$\frac{1}{9{\cdot}4}$	60	Imm., flattening of ♃. Em., dark shade.
Criswick (Greenwich, W. Equat^{l}.)	3 0	3·6	$\frac{1}{10}$	...	Em., projection of ♃'s limb.

[1] Astronomical Society's *Memoirs*, Vol. xvi. p. 301.

Observer.	Focal Length = F. ft.	in.	Aperture = A. in.	Ratio $\frac{A}{F}$	Power.	Phenomena.
Glaisher (Greenwich, 30-in. Achr.)	2	6	2·7	$\frac{1}{11·1}$	...	None.
Huggins	5	0	5·0	$\frac{1}{12}$	50	None.
Lassell (Newtonian)	20	0	20·0 (reduced)	$\frac{1}{12}$	316	Imm., distortion of ♅; Em., dark shade.
Lowndes (Adm^{l} Smyth's Equatoreal)	8	6	5·9	$\frac{1}{12·1}$	240	Imm., distortion of ♅.
Dawes (Alvan Clark)	10	0	8·0	$\frac{1}{12·5}$	160	Imm., light on dark limb of ☽.
Ellis (Greenwich, 46-in. Achr.)	3	10	3·6	$\frac{1}{13}$	170	None.
Simms (1)	2	6	2·25	$\frac{1}{13·3}$	...	Em., dark shade.
Grove (Binocular)	4	3	3·37	$\frac{1}{13·4}$	60	None, though looked for.
Watson (Newtonian)	9	0	8·0	$\frac{1}{13·5}$	100	None.
Mann	4	0	3·5	$\frac{1}{13·6}$	120	Em., ♅ preceded by patch of light on moon (projection?) Dark shade.
Simms (2)	6	4	5·5	$\frac{1}{13·8}$	...	Em., dark shade.
Lord Wrottesley	10	9	7·75	$\frac{1}{14·1}$	140	Imm., light on dark limb of ☽.
Main (Greenwich, S. Equat^{l}.)	8	2	6·7	$\frac{1}{14·6}$	...	Imm., distortion of limb of ♅; bright band on ♅; repetition of disappearance.
Brodie (1)	9	5	7·45	$\frac{1}{15·1}$	106	Imm., projection of sat.; light outside limb of ☽ after disappearance.
Webb	5	6	3·7	$\frac{1}{15·2}$	144	Imm., light on limb of ☽ after disappearance. Em., dark shade.
Burr	4	4	3·38	$\frac{1}{15·4}$	173	Imm., light on limb of ☽.
Peto	5	0	3·875	$\frac{1}{15·4}$	120	Em., projection of ♅, with dark shade (*qy.* same as Challis?)
Dunkin (Greenwich, N. Equat^{l}.)	5	4	4·1	$\frac{1}{15·8}$	...	Imm., light on dark limb of ☽.
Lynn (Greenwich, Altazimuth.)	5	0	3·75	$\frac{1}{16}$	...	None.

Observer.	Focal Length = F.	Aperture = A.	Ratio $\frac{A}{F}$	Power.	Phenomena.
	ft. in.	in.			
Hodgson	8 0	6·0	$\frac{1}{16}$	160	None.
Pogson	10?	7·2	$\frac{1}{16·7}$	93	None.
Johnson (Heliometer)	10 5	7·5	$\frac{1}{16·8}$	150	None.
Hartnup	12 0	8·5	$\frac{1}{16·9}$	134	Em., projection of sat.
Simms (3)	22 0	15·0	$\frac{1}{17·6}$	200	Imm., distortion of ♃.
Slatter	7 4	4·9	$\frac{1}{17·9}$	87	Em., sat. adhered, and suddenly separated.
Simms (4)	22 0	13·0	$\frac{1}{20·3}$	200	Em., dark shade.
Challis (Northumberl^{d})	19 6	11·5	$\frac{1}{20·3}$	215	Em., ♃ as if in a hollow of ☽; dark shade (*qy.* projection ?)
Brodie (2) a friend, (Dr. Pearson's)	12 0	6·8	$\frac{1}{21}$	...	Same as Brodie (1).

Occultation of Jupiter by the Moon, November 8, 1856.

(*Astronomical Society's Notices*, vol. xvii. No. 1.)

Observer.	Focal Length = F.	Aperture = A.	Ratio $\frac{A}{F}$	Power.	Phenomena.
	ft. in.	in.			
De La Rue (1) (Newtonian)	9 $11\frac{1}{2}$	13·0	$\frac{1}{9·2}$	...	None.
Huggins	5 0	5·0	$\frac{1}{12}$	176 (corrected)	♃ grazed ☽.
Grove	1 10	1·75	$\frac{1}{12·5}$	43	Imm., junction of limbs; dark shade.
De La Rue (2) (Achrom.)	3 0	2·5	$\frac{1}{14·4}$	...	None.
Burr	4 4	3·38	$\frac{1}{15·4}$	...	Imm., ♃ grazed ☽; dark shade.
(also Jan. 2d) Goddard	6 2	4·125	$\frac{1}{17·9}$	200	Imm., adhesion; dark shade.

Eclipse of Jupiter's First Satellite, January 3, 1857.

Observer.	Focal Length = F.	Aperture = A.	Ratio $\frac{A}{F}$	Power.	Phenomenon.
	ft.	in.			
Hodgson	8	6	$\frac{1}{16·0}$	140	Projection of sat. on ♃.

Occultation of Jupiter by the Moon, August 19, 1856 (*Canada*).

(*Astronomical Society's Notices*, vol. xii. p. 221.)

Observer.	Focal Length = F.	Aperture = A.	Ratio $\frac{A}{F}$	Power.	Phenomenon.
	ft in.	in.			
Chalmers	3 16	2·75	$\frac{1}{14·4}$	60	Apparent repulsion of contact.

"From this tabular view it appears that all the cases of projection (or what appear such),—or others which may be conceived due to similar optical causes,—occur with telescopes having ratios between $\frac{1}{13}$ and $\frac{1}{20}$; with the single exception of that of Mr. Criswick, with a ratio of only $\frac{1}{10}$. Yet that gentleman's description of the phenomenon is graphically what ought to be the optical effect due to enlargement of the disk.

"We have as yet no data for assigning the limits of this telescopic ratio for producing enlargement of disks; but generally in this instance they do not appear to follow any perceptible relation to the size or perfection of the instruments. We must still suppose them in a great degree due to *ocular* causes as yet little understood."

Abstract of a Paper "On the Horary Variation of Meteors."
By G. C. Bompas, Esq.

(*Communicated by Professor De Morgan.*)

The fact of a *horary* variation in the number of shooting stars observed has been established by the researches of Coulvier Gravier, Saigey, and others.—(*Recherches sur les Etoiles Filantes*, Paris, 1845; and Humboldt *Cosmos*, iii. 440.)

The following table contains a summary of these results:—

Hours, P.M.	6 to 7	7 to 8	8 to 9	9 to 10	10 to 11	11 to 12
Mean No. of Meteors.	3·3	3·5	3·7	4	4·5	5

Hours, A.M.	12 to 1	1 to 2	2 to 3	3 to 4	4 to 5	5 to 6
Mean No. of Meteors.	5·8	6·4	7·1	7·8	8	8·2

Thus it appears that the minimum occurs at 6 P.M.; the mean at midnight; and the maximum at 6 A.M.; and that two-thirds of the whole number appear between midnight and 6 A.M.

If we designate the number coming from N, S, E, and W, by those initials respectively, then $E > 2W$, $N = S$ nearly, but $E + W = N + S$.

Coulvier Gravier observes,—"But for *the cause* which transfers from the west to the east nearly one-half the number due to each of these directions, there would come exactly the same numbers of shooting stars from the four points of the compass." But he does not state what that cause is.

From the results of all these observations it appears that the greatest *heights* at which meteors appear bear no more than a very small proportion to the earth's diameter.

Boguslawski considers the average *velocity* of meteors to be about *double* the velocity of the earth in its orbit.—(*Etoiles Filantes*, p. 102.)

The part of the heavens towards which the earth is moving at any time is always 6^h from the $\odot$. At 6 A.M. the observer's meridian is in the direction of the earth's motion: and at 6 P.M. in the opposite.

Thus the greatest number of meteors are encountered when the observer's meridian is in the direction of the earth's motion; and the number diminishes from thence to 6 P.M., when he looks the opposite way.

Combining these facts, the author explains the results (illustrated by a diagram), on the principle that if the meteors be distributed equally in space they would converge to the earth, if at rest, equally on all sides.

But if the earth be in motion, and with a velocity one-half the average velocity of the meteors, they would converge to it more on the side towards which it is moving than the other: and, in the proportion of nearly two-thirds of the number, would have an apparent motion more or less opposed to that of the earth, and apparently diverging from the point towards which the earth is moving with a gradual increase in number from 6 P.M. to 6 A.M.

The work of Coulvier Gravier and Saigey here referred to contains a very full historical summary of all that has hitherto been done in the study of meteors, and was apparently intended as the preface to a series of observations which, so far as we are aware, has not yet appeared. The work of Mr. Schmidt, *Resultate aus zehnjahrigen Beobachtungen über Sternschnuppen*, published in 1852, requires no recommendation to readers of German.

Extract from a Letter from Professor Argelander.

"I have read with much pleasure in the last number of the *Monthly Notices* the paper of Mr. Pogson on variable stars. Mr. Pogson has, by his communication on these interesting objects, acquired new laurels; and every one who is employed in observations of them will thank him for his published times of maxima

and minima. For the stars which are constantly visible the knowledge of these times is in some respects of less importance, and it is very much to be wished that they should be closely looked after in all stages of their variability, and be observed by many more astronomers. But for the great number of these stars, which are only visible for a short time even in large telescopes, a previous approximate knowledge of their times is indispensably necessary for the observer to escape from the needless loss of time caused by frequent fruitless searches. Indeed without such previous warning many a phenomenon would pass altogether unobserved.

"The numbers given by Mr. Pogson do not, however, appear to be all based on the most certain elements; for instance, those for the older stars seem for the most part to be derived from my contributions to the *Cosmos* of Humboldt. Since the publication of these contributions our knowledge of the elements of the variability of many of those changing stars has, however, been greatly increased, so that the older elements are now comparatively no longer of use. I beg, therefore, to communicate some corrections, with the request that they may be made known through the *Monthly Notices*.

"I give, firstly, the times of maxima in the present year for those stars for which my further researches have supplied corrections to my earlier elements:—

R Cancri,	Maximum, 1857,	Feb.	23
R Leonis,	—	— June	21
S Serpentis	—	— April	5
R Serpentis	—	— Sept.	29
χ Cygni	—	— Dec.	19
R Pegasi	—	— March	5
R Aquarii	—	— April	16
μ Cephei	—	— April or May.	

μ Cephei is Herschel's Garnet star.

"α *Cassiopeæ*, ε *Aurigæ*, R *Coronæ*, and β *Pegasi* are only occasionally variable; R *Hydræ*, α *Herculis*, and R *Scuti*, are, as Mr. Pogson has already remarked, very irregular: the minima of R *Scuti* ought to occur about Feb. 9, April 21, July 2, Sept. 12, and Nov. 23, and the maxima 40 days after the minima; but these times may fluctuate 15 or 20 days.

"For the calculation of the epochs of the short-period-variables the following data are available:—

ζ Geminorum — Minimum, 1857, Feb. $7^d\ 7^h{\cdot}2$, G.M.T.
Period, $10^d\ 3^h\ 48^m{\cdot}0$. Max. $5^d\ 5^h{\cdot}5$ after the Min.

Observations are well represented by the formula,—

$$1857, \text{Jan. } 7^d\ 19^h\ 51^m{\cdot}2 + 10^d\ 3^h\ 47^m\ 59^s{\cdot}4\ E + 1^s\ E^2;$$

where E is the number of periods elapsed from 1857, Jan. 7.

β Lyræ — Principal minimum, 1857, Feb. $6^d\ 1^h\ 54^m{\cdot}0$, G.M.T.
Period, $12^d\ 21^h\ 45^m\ 12^s$. First max. $3^d\ 2^h$; second min. $6^h\ 8^h{\cdot}5$, and second max. 9^h 10^d after the minimum.
Its periods are slowly decreasing.

η Aquilæ — Minimum, 1857, Feb. $6^d\ 14^h\ 3^m{\cdot}2$, G.M.T.
Period, $7^d\ 4^h\ 14^m\ 4^s$. Max. $2^d\ 9^h$ after the min.

δ Cephei — Minimum, 1857, Feb. $6^d\ 1^h\ 14^m{\cdot}3$, G.M.T.
Period, $5^d\ 8^h\ 47^m\ 40^s{\cdot}0$. Max. $1^d\ 14^h{\cdot}4$ after the min.

"It is much to be wished that observers in the southern hemisphere would attend to the observation of R *Hydræ*. This star is visible but for a very short time to us, especially if it is not observed in the morning, a time when the professional astronomer can seldom attend to it. Besides which, suitable stars of comparison at the maximum are wanting: ψ and γ *Hydræ* being so very different in brightness that the comparison can no longer be made with security when the variable is between the two, and thereby the time of maximum is very uncertain.

"Comparison-stars of intermediate brightness, which are only to be found in *Scorpio*, are too low on our horizon in Europe to be used with advantage. All these difficulties are absent to the southern observer. It is to these obstacles that we must attribute the circumstance that the elements of variability of a star so long known as this one has been are still almost wholly unknown. Its period is now manifestly shorter than it was 150 years ago, but the want of a continuous series of observations prevents our drawing any conclusions respecting its rate of diminution; and if our information is to be confined to observations procured in the northern hemisphere, it may, perhaps, happen that 150 years hence we may not know much more about it than at present."

Supplement to the Solar Tables of Messrs. Hansen and Olufsen. By P. A. Hansen.

(*Communicated by the Astronomer Royal.*)

In calculating the positions of the Sun for certain ancient eclipses, I have found that by means of the terms of the first and second order depending on the precession, of which Mr. Olufsen and I have taken account in our tables, we do not obtain the position of the Sun for times so distant from the epoch of the tables with all the precision which is desirable. I feel bound, accordingly, to add the terms of the third and fourth order, which have a sensible effect at those distant dates. By carrying farther

the developments we find in the quantities designated by Z and W the following terms:—

In Z,

$$\left\{\begin{array}{llll} \text{,,} & +0''.001979 \sin(g''+Xt) & +0''.000084 \sin 2(g''+Xt) \\ -0''.000469 & +0''.007912 \cos(g''+Xt) & +0''.000037 \cos 2(g''+Xt) \end{array}\right\} T^3$$

$$+\left\{\begin{array}{llll} & -0''.0000015 \sin(g''+Xt) & +0''.0000015 \sin 2(g''+Xt) \\ -0''.0000002 & -0''.0000009 \cos(g''+Xt) & -0''.0000003 \cos 2(g''+Xt) \end{array}\right\} T^4$$

In W,

$$\left\{\begin{array}{llll} -0''.00074 & -0''.02081 \cos(g''+Xt) & -0''.00122 \cos 2(g''+Xt) \\ & +0''.08341 \sin(g''+Xt) & +0''.00175 \sin 2(g''+Xt) \end{array}\right\} T^3$$

$$+\left\{\begin{array}{llll} -0''.000018 & +0''.000014 \cos(g''+Xt) & -0''.000015 \cos 2(g''+Xt) \\ & -0''.000011 \sin(g''+Xt) & -0''.000005 \sin 2(g''+Xt) \end{array}\right\} T^4$$

where $$T = \frac{t - 1850}{100}$$

In the Solar Tables we have not included the preceding terms, which, in point of fact, amount to a few seconds only for a thousand years before or after their epoch, considering such an approximation to be sufficient. But as some of the ancient eclipses reach back to more than 2500 before the epoch of the tables, and for this interval of time the terms involving T^3 may amount to more than two minutes, we cannot neglect them when we wish to know exactly the results of the lunar tables for these eclipses.

I supply, then, on this occasion the necessary tables for these terms, with the addition of the coefficients of T^4, although the latter amount to a few seconds only, even for 2500 years. The units adopted are the same as in the Solar Tables, namely, in the first table, the fifth decimal figure of Argument I., and in the second table the seventh decimal figure of the logarithm of the radius vector. As a unit of the fifth decimal figure of Arg. I. corresponds to $0''.03$, and for eclipses we do not require seven decimals in the logarithm of the radius vector, the number of decimals employed in these tables will be sufficient. The numbers of these two tables are to be taken out with Arg. V. + Arg. XIII. of the Solar Tables + the day of the year.

As an example, I will calculate the position of the sun for the year −399, June 21^d 6^h Greenwich mean time, which is the time of the eclipse of Ennius, mentioned by Cicero.

In Paris mean time this date is,

$$= -400^y + 1^y + 172^d.25650$$
$$= -400^y + 1^y.470$$

and with these dates we find from the Solar Tables the following values of the Arguments, to which the day of the year has been added, where required,—

Arg. I	= 169·83726	Arg. V + XIII	= 188·320	Arg. X	= 36·47
— II	= 1369	— VI	= 37·49	— XI + XIII	= 5364
— III	= 37	— VII	= 32·93	— XII + XIII	= 454
— IV	= 32	— VIII	= 58·39	— XIII	= 197·900
		— IX	= 7·9	— XIV	= 206·39

From Tables IX. and X, of the Solar Tables, and from the first of the tables below we deduce the numbers,

$$117''\cdot171\,;\ -5''\cdot40\,;\ -0''\cdot238\,;\ +0''\cdot00002\,;$$

which must be multiplied by

$$-22''\cdot49\,;\ (-22''\cdot49)^2\,;\ (-22''\cdot49)^3\,;\ (-22''\cdot49)^4\,;$$

which gives,

$$\begin{aligned} &-263518\\ &-\ 2731\\ &+\ 2707\\ &+\ \ 5\\ \text{Sum} = &-263537 \end{aligned}$$

and from the other tables of the inequalities of Arg. I. we find the sum of the inequalities $=160$; consequently

Arg. I + its inequalities = 167·21790

by means of which Table XXXIV. gives

The apparent tropical longitude $= 83^\circ\,45'\,49''\cdot9$

Next, from Tables XX. and XXI. of the Solar Tables, and from the second table below, we get the numbers

$$-0''\cdot421\,;\ +1''\cdot11\,;\ +0''\cdot014\,;\ -0''\cdot00005\,;$$

which must be multiplied by the same numbers which we have just mentioned; whence we have

$$\begin{aligned} &+\ 945\\ &+\ 561\\ &-\ 159\\ &-\ \ 13\\ \text{Sum} + &\ 1334 \end{aligned}$$

And from the other tables we obtain the sum of the other inequalities of the logarithm of the radius vector $= 634$. Now, as Table XXXV. gives 0·0068721 for the principal term of this logarithm we shall have, by the addition of the inequalities which we have just calculated,—

Log. radius vector = 0·0070689.

We can verify this result by computing directly the sidereal longitudes and the logarithm of the radius vector, and then adding

the precession and aberration. As, from the beginning of the year 1800 to the beginning of the year 1850 there are 50 Julian years less by 0·5 days, and the difference of the calendar in this century is 12 days, we have for the epoch of the tables,

$$1850^y - 12^d{\cdot}5.$$

In the next place, as year -399 is the first after the preceding bissextile, we must deduct $0^d{\cdot}25$ from the given time, which consequently becomes

$$-399^y + 172^d{\cdot}00650.$$

The difference between these two times is

$$-2249^y + 184^d{\cdot}50650;$$

for which we must compute the sidereal movement. Now as the Solar Tables give for the Julian year this movement $=360^\circ - 22''{\cdot}56009$, we find for the above interval of time

$$195^\circ\ 56'\ 42''{\cdot}4;$$

by adding to which $c'' = -33'\ 46''{\cdot}3$, we get

$$g'' = 195^\circ\ 22'\ 56''{\cdot}1;$$

and with this value of g'' we find the secular variations of the expressions for $n''\,t''$, and w'', given in the Solar Tables,

$$= +\ 0''{\cdot}41114\ (t - 1850) - 0''{\cdot}04390\ \left(\frac{t-1850}{100}\right)^2$$

$$\text{and} = -\ 0\cdot6726\ \ (t - 1850) - 1\cdot684\ \ \left(\frac{t-1850}{100}\right)^2$$

where $t - 1850 = -2248{\cdot}5$. Computing these, we find the secular variations of $n''\,t'' = -15'\ 46''{\cdot}7$; and as the sum of the constants added in the Solar Tables to the other inequalities of Arg. I. is $=1791$, the sum of the inequalities found above becomes $= -6''{\cdot}7$, after conversion into seconds. By adding these two numbers to the value of g'', we have

$$n''\,t'' = 195^\circ\ 7'\ 2''{\cdot}7;$$

and with this value we find the equation of the centre

$$= -\ 29'\ 28''{\cdot}6.$$

Now, as the longitude of the perigee $= 280^\circ\ 21'\ 41''{\cdot}0$, by adding these numbers to the value of $n''\,t''$, we find the sidereal longitude $=114^\circ\ 59'\ 15''{\cdot}1$.

Next, Tables XLI. and XLII. give the precession $= -3^\circ\ 13'\ 5''{\cdot}5$, and Table XLV. gives the aberration $=19''{\cdot}9$; consequently the apparent tropical longitude $=83^\circ\ 45'\ 49''{\cdot}7$, which differs from the longitude previously found by the table by only $0''{\cdot}2$.

With the same value of $n''\,t''$ we find the principal term of the log. radius vector, less by the sum of the constants added to the tables of its inequalities, $=0{\cdot}0069409$. After having performed

the multiplications, the secular inequalities mentioned above become +661, and the other inequalities computed above were =634; whence

Log. radius vector = 0·0070704,

and the difference from the value found previously from the tables is 0·0000015, which is sufficient for our purpose.

Table I. — *Inégalités de l'Arg. I. des Tables du Soleil.*

Arg. V. + Arg. XIII. + le Jour de l'Année.

Arg.	Inégalité à Mult. p. $\left(\frac{t-1850}{100}\right)^3$	Diff.	Inégalité à Mult. p. $\left(\frac{t-1850}{100}\right)^4$	Arg.	Inégalité à Mult. p. $\left(\frac{t-1850}{100}\right)^3$	Diff.	Inégalité à Mult. p. $\left(\frac{t-1850}{100}\right)^4$
0	+0·209		−0·00004	192	−0·240		+0·00003
8	+0·216	+ 7	−0·00004	200	−0·241	− 1	+0·00004
16	+0·219	+ 3	−0·00003	208	−0·238	+ 3	+0·00006
24	+0·217	− 2	−0·00002	216	−0·231	7	+0·00007
32	+0·211	6	−0·00002	224	−0·220	11	+0·00008
40	+0·200	11	−0·00001	232	−0·205	15	+0·00009
48	+0·186	14	−0·00001	240	−0·186	19	+0·00009
56	+0·167	19	−0·00001	248	−0·164	22	+0·00008
64	+0·145	22	−0·00001	256	−0·140	24	+0·00008
72	+0·120	25	−0·00002	264	−0·113	27	+0·00007
80	+0·092	28	−0·00003	272	−0·085	28	+0·00005
88	+0·062	30	−0·00003	280	−0·055	30	+0·00004
96	+0·031	31	−0·00004	288	−0·024	31	+0·00002
104	−0·001	32	−0·00005	296	+0·007	31	+0·00001
112	−0·033	32	−0·00006	304	+0·038	31	−0·00001
120	−0·065	32	−0·00007	312	+0·068	30	−0·00002
128	−0·095	30	−0·00007	320	+0·097	29	−0·00003
136	−0·124	29	−0·00007	328	+0·124	27	−0·00004
144	−0·150	26	−0·00006	336	+0·148	24	−0·00005
152	−0·174	24	−0·00005	344	+0·169	21	−0·00005
160	−0·195	21	−0·00004	352	+0·187	18	−0·00005
168	−0·212	17	−0·00002	360	+0·201	14	−0·00004
176	−0·225	13	−0·00001	368	+0·212	11	−0·00004
184	−0·235	10	+0·00001	376	+0·218	6	−0·00003
192	−0·240	− 5	+0·00003	384	+0·219	+ 1	−0·00003

Table II. — *Inégalités du Logarithme du Rayon Vecteur du Soleil.*

Arg. V. + Arg. XIII. + le Jour de l'Année.

Arg.	Inégalité à Mult. p. $\left(\frac{t-1850}{100}\right)^3$	Diff.	Inégalité à Mult. p. $\left(\frac{t-1850}{100}\right)^4$	Arg.	Inégalité à Mult. p. $\left(\frac{t-1850}{100}\right)^3$	Diff.	Inégalité à Mult. p. $\left(\frac{t-1850}{100}\right)$
0	−0·026		−0·00002	192	+0·009		−0·00005
8	−0·014	+12	−0·00002	200	−0·003	−12	−0·00004
16	−0·001	13	−0·00002	208	−0·014	11	−0·00004
24	+0·011	12	−0·00002	216	−0·025	11	−0·00004
32	+0·023	12	−0·00002	224	−0·035	10	−0·00003
40	+0·035	12	−0·00002	232	−0·045	10	−0·00002
48	+0·046	11	−0·00002	240	−0·055	10	−0·00002
56	+0·055	9	−0·00002	248	−0·063	8	−0·00001
64	+0·064	9	−0·00002	256	−0·070	7	0·00000
72	+0·072	8	−0·00002	264	−0·076	6	0·00000
80	+0·078	6	−0·00001	272	−0·081	5	+0·00001
88	+0·082	4	−0·00001	280	−0·084	3	+0·00001
96	+0·085	3	−0·00001	288	−0·086	− 2	+0·00001
104	+0·086	+ 1	−0·00002	296	−0·086	0	+0·00001
112	+0·085	− 1	−0·00002	304	−0·085	+ 1	+0·00001
120	+0·083	2	−0·00002	312	−0·082	3	+0·00001
128	+0·079	4	−0·00002	320	−0·077	5	+0·00001
136	+0·074	5	−0·00003	328	−0·071	6	0·00000
144	+0·067	7	−0·00003	336	−0·063	8	0·00000
152	+0·059	8	−0·00004	344	−0·054	9	−0·00001
160	+0·051	8	−0·00004	352	−0·044	10	−0·00001
168	+0·041	10	−0·00005	360	−0·033	11	−0·00002
176	+0·031	10	−0·00005	368	−0·022	11	−0·00002
184	+0·020	11	−0·00005	376	−0·010	12	−0·00002
192	+0·009	−11	−0·00005	384	+0·003	+13	−0·00002

On a Numerical Solution of Kepler's Problem, reduced to a Tabular Form. By Dr. A. De Gasparis.

(*Extracted from Letters addressed to Mr. Hind.*)

"I have constructed a numerical table for the solution of Kepler's problem. This table, which extends to 23 pages, similar

in size to those of Callet, gives, by simple inspection, the value of the excentric anomaly within about a degree, for any excentricity less than unity. By proportional parts we get the value of our unknown quantity to a fraction of a minute, and then by a calculation of the correction $\Delta\varepsilon$ by the formula

$$\Delta\varepsilon = \frac{M - \varepsilon + e \sin \varepsilon}{1 - e \cos \varepsilon}$$

we get it within a fraction of a second.

"The table, consequently, contains all possible solutions of the equation

$$M = \varepsilon - e \,.\, \sin \varepsilon$$

for whole-degree values of M and ε, and for values of e less than 1. It would not be difficult to obtain these solutions directly, but the calculation would be long, and there is the objection that we cannot beforehand estimate its extent. Allow me to explain the process I have followed.

"I remarked that if we wish to solve practically (say by a mechanical process) the equation

$$m = x \pm n \,.\, \varphi(x)$$

in which the function φ is one of those which has been tabulated, we must mark on a rule the logarithms of the numbers c_1, c_2, c_3, &c., found by the equations

$$h = c_1 \varphi(h) = c_2 \varphi(2h) = c_3 \varphi(3h), \text{ \&c.}$$

and place above them the numbers h, $2h$, $3h$, &c. The number h is arbitrary. This done, we must mark on another rule either from right to left, or from left to right, the logarithms of the numbers 0, 1, 2, 3, &c. If, now, we want to find the roots of the equation

$$m = x \pm n \varphi(x)$$

we must find on the first rule a number ph nearly equal to m; place it beneath the $-\infty$ of the second rule, and take at sight the sums of the logarithms of c_n of the first rule and the corresponding logarithms of the natural numbers on the second rule. The sum which gives the logarithm of n will be found at the part of the rule under the number qh; and this number will be the approximate root. We may correct this value by the proportions which are found of themselves by placing the symbol $-\infty$ first under the number next less than m, and, secondly, under the number next greater than m.

"In the case of Kepler's problem, I have taken $h = 1°$. I have then deduced the solutions which I wanted by the simple addition of the logarithms which are found at corresponding points on the two rules; and I have stopped the calculations in all cases where the logarithm of the sum exceeded zero.

"The following table is equivalent to two-fifths of the twenty-three pages of which the whole table is composed. In the example

subjoined, after the calculation of proportional parts, I find the correction by means of the formula $\Delta\varepsilon = \frac{M - \varepsilon + e \sin \varepsilon}{1 - e \cos \varepsilon}$.

Specimen of Table.

M	e	ε	M	e	ε	M	e	ε	M	e	ε
°		°	°		°	°		°	°		°
26	0·36054	39	26	0·80389	69	27	0·40946	43	27	0·83954	73
26	0·38014	40	26	0·81723	70	27	0·42713	44	27	0·85536	74
26	0·39905	41	26	0·83066	71	27	0·44429	45	27	0·86731	75
26	0·41734	42	26	0·84417	72	27	0·46100	46	27	0·88139	76
26	0·43506	43	26	0·85779	73	27	0·47729	47	27	0·89562	77
26	0·45225	44	26	0·87152	74	27	0·49320	48	27	0·91001	78
26	0·46897	45	26	0·88538	75	27	0·50877	49	27	0·92456	79
26	0·48526	46	26	0·89938	76	27	0·52403	50	27	0·93930	80
26	0·50115	47	26	0·91353	77	27	0·53900	51	27	0·95423	81
26	0·51669	48	26	0·92785	78	27	0·55372	52	27	0·96937	82
26	0·53189	49	26	0·94234	79	27	0·56820	53	27	0·98473	83
26	0·54681	50	26	0·95702	80	27	0·58248	54	27	1·00032	84
26	0·56146	51	26	0·97190	81	27	0·59658	55	28	0·03600	29
26	0·57586	52	26	0·98699	82	27	0·61052	56	28	0·06981	30
26	0·59006	53	26	1·00231	83	27	0·62432	57	28	0·10166	31
26	0·60406	54	27	0·03718	28	27	0·63800	58	28	0·13174	32
26	0·61789	55	27	0·07200	29	27	0·65157	59	28	0·16023	33
26	0·63158	56	27	0·10472	30	27	0·66506	60	28	0·18727	34
26	0·64513	57	27	0·13555	31	27	0·67848	61	28	0·21300	35
26	0·65858	58	27	0·16468	32	27	0·69185	62	28	0·23755	36
26	0·67193	59	27	0·19227	33	27	0·70518	63	28	0·26101	37
26	0·68521	60	27	0·21848	34	27	0·71849	64	28	0·28349	38
26	0·69844	61	27	0·24343	35	27	0·73179	65	28	0·30507	39
26	0·71162	62	27	0·26724	36	27	0·74510	66	28	0·32583	40
26	0·72477	63	27	0·29001	37	27	0·75842	67	28	0·34584	41
26	0·73791	64	27	0·31184	38	27	0·77178	68	28	0·36517	42
26	0·75105	65	27	0·33280	39	27	0·78519	69	28	0·38387	43
26	0·76420	66	27	0·35298	40	27	0·79866	70	28	0·40200	44
26	0·77739	67	27	0·37245	41	27	0·81220	71	28	0·41961	45
26	0·79061	68	27	0·39125	42	27	0·82582	72	28	0·43673	46

Example.— Let the equation be $26°·35794 = \varepsilon - 0·82575 \sin \varepsilon$.

For $M = 26°$, and by variation of e we find $\varepsilon = 70°·63440$.

For $M = 27°$, and by variation of e we find $\varepsilon = 71°·99486$.

Whence for M = 26°·35794, we shall have ε = 71°·12136.

The error is 0°·003. The correction $\Delta\varepsilon$ comes out + 0·00472."

Whence, lastly, ε = 71°·12608. Error = 0°·000003.

An Expeditious Method of finding the Latitude by simply observing the Azimuthal Angles of two Circumpolar Stars with a Theodolite. By M. Babinet.

(*Communicated by Admiral W. H. Smyth.*)

It is presumed that the method is designed to meet the case of a traveller, who, from other considerations, has been led to take with him a small theodolite and pocket-chronometer, to the exclusion of a sextant or repeating circle; and that he has with him a catalogue of the brighter stars. Regarded otherwise, the method would be much inferior to others already known.

In the well-known triangle Z P S, let Z be the zenith, P the pole, and S the place of a circumpolar star. $ZP = 90 - \lambda$. $PS = \delta$. $PZS = A$, the azimuth of the star.

Then

$$\sin A \cdot \cos\lambda = \sin\delta \cdot \sin PSZ$$

It is proposed that the star's azimuth shall be observed when at its greatest elongation, in which case $PSZ = 90°$, and the above equation becomes

$$\sin A \cdot \cos\lambda = \sin\delta \qquad (1)$$

Similarly for the second star we should have

$$\sin A' \cdot \cos\lambda = \sin\delta' \qquad (2)$$

Dividing (1) − (2) by (1) + (2), we then have

$$\frac{\tan\frac{1}{2}(A-A')}{\tan\frac{1}{2}(A+A')} = \frac{\tan\frac{1}{2}(\delta-\delta')}{\tan\frac{1}{2}(\delta+\delta')} \qquad (3)$$

When the two stars are observed at opposite elongations, A and A′ will have opposite signs, and A + A′ will be found at once from the difference of the two readings of the horizontal circle, half the difference will be

$$\tfrac{1}{2}(A + A')$$

By equation (3) we thence get

$$\tfrac{1}{2}(A - A')$$

Thence A and A′ separately, and by either (1) or (2) the required latitude λ.

Having found from A or A′ the azimuthal reading of the pole, we can then set the telescope in the meridian, and obtain the time very nearly by a transit of an intertropical star. The whole operation need not take more than twenty minutes, if the stars are previously suitably selected.

M. Babinet gives the following example for a place, the latitude of which is 51° 49′ north. Suppose the theodolite levelled, and the reading of the horizontal circle for the azimuth of the pole to be 67° (unknown); suppose, further, the two stars selected to be

		h	m		°	′
ε Cassiopeæ	R.A. =	1	44	N.P.D. =	27	3

and

o Urs. Maj.		8	18		28	48

and the observation to be made on the 1st of March, 1857.

A rough preliminary calculation by the relation

$$\cos h = \tan \delta \,.\, \tan \lambda$$

made with a guessed value of λ will show that ε *Cassiopeæ* will attain its greatest east elongation at about $6^h\ 24^m$ after noon, and o *Urs. Maj.* its greatest west elongation at about $6^h\ 37^m$, the second observation following the first in about 13 minutes.

The horizontal circle-readings will be respectively for ε *Cassiopeæ* 114° 21′·2; for o *Urs. Maj.* 15° 48′·1; whence we find

$$\tfrac{1}{2}(A+A') = +49^\circ\ 16'.6$$

and by (3),

$$\tfrac{1}{2}(A-A') = -\ 1\ 55'.0$$

$$A = 47\ 21'.6 \text{ East}$$

$$A' = 51\ 11'.6 \text{ West}$$

and by either (1) or (2),

$$\lambda = 51\ 49$$

To ascertain how the result would be affected by errors of observation, differentiate the equations (1) and (3), and it will be found that

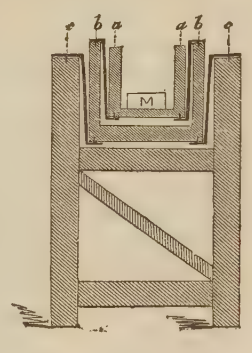
$$d\lambda = \cot \lambda \,.\, \frac{\cos A \,.\, \cos A'}{\sin (A + A')} \,.\, d(A + A');$$

whence we may conclude that for such a pair of stars as the above, the error of the resulting latitude will scarcely exceed one-third of the error of the observed difference of azimuths.

At the conclusion of the ordinary business of the meeting, the Astronomer Royal exhibited and explained a model of the stand now in use at the Royal Observatory for the support of the mercury vessel of the reflex-zenith-tube. Considerable difficulty had been experienced, as is well known, in the use of this instrument on its first establishment, from the constant presence of tremor, and it was twice taken down and remounted in new positions, with little, if any, relief from the annoyance sought to be avoided. Indeed, the continual agitation of the artificial horizon seemed to testify to a never-ceasing palpitation of the soil of the Greenwich hill. After alluding to the expedients which were previously and vainly resorted to, and which are recounted in the Annual Reports

to the Board of Visitors, the Astronomer Royal turned to the model, and remarked that, at first sight, perhaps nothing could look more unpromising than the arrangement before his audience, the parts of which admitted of free motion in every direction, and seemed directly and intentionally opposed to the ideas of fixity and permanence.

The mercury vessel M rests on the bottom of a wooden frame *a a*, supported by broad bands of vulcanised caoutchouc attached to a second frame *b b*, which is itself similarly connected with a very solid stand *c c*. The vertical tremors were found to be entirely annihilated by this mode of suspension, and there remained only a slight horizontal swimming of the image which was at once cut off by connecting frames *a* and *c* horizontally by two fine shreds of the same elastic material. The vibrations of the soil are thus spent upon the elastic parts of the apparatus, and the inertia of the supported parts allowed to have free and beneficial action.



The subject has been already touched upon in the Annual Report, but the woodcut may make the explanation of the arrangement a little clearer.

Mr. William Taylor, in a letter to one of the Secretaries, says that he has found an artificial horizon of pitch a very convenient one under certain circumstances, such as when a reflexion observation has to be obtained in a situation much exposed to wind. He recommends heating the pitch in a flat pan, filtering it through muslin, and conveying the pan, with the pitch still in a thoroughly fluid state, to the support on which it is intended to rest, leaving it to cool with a cover over it. He remarks that a perfectly horizontal surface is thus obtained, a fact we should be much inclined to doubt, where the vessel and support have thus been greatly heated and cooled.

Two New Comets.

A comet was discovered by Professor D'Arrest at Leipsic on the 22d of February, in the following position,—

1857, Feb. 22. $16^h\ 40^m$ Leipsic M.T., R.A. 320° 37′ N.P.D. 67° 56′

The following two positions have been obtained at Redhill,—

1857	G.M.T. h m s	App. R.A. h m s	App. N.P.D. ° ′ ″	Comps.	Stars.
Feb. 28	17 23 32	21 43 28·9	63 5 27	3	*a*, *b*,
March 23	9 24 1	0 37 58·0	44 8 38	3	*c*, *d*.

Assumed mean places of stars, 1857·0.

		h m s	° ′ ″
a	Lal. 42416 and Bessel	21 37 30·00	62 48 24·0
b	— 42436 and Bessel	21 38 56·10	63 39 25·0
c	— 1222 and Rümker	0 38 40·10	43 53 19·0
d	— 1314 and Oeltzen	0 41 31·50	44 16 15·0

Elements computed by Dr. Donati of Florence were forwarded by Mr. Drach. The most reliable up to the present time are, however, those of Mr. Pape of Altona, viz.

T	March 21·39349	Berlin M.T.
π	74 49 11·4	M. Eq. 1857·0
Ω	313 12 58·2	
i	87 57 6·7	
Log. *q*	9·887693	Motion direct.

From these are deduced the following approximate positions for April, at Berlin midnight:—

	R.A. h m s	N.P.D. ° ′		R.A. h m s	N.P.D. ° ′
April 3	3 1 56	46 10	April 9	4 3 20	51 31
4	13 26	46 55	10	11 54	52 32
5	24 24	47 45	11	20 0	53 34
6	34 52	48 38	12	27 40	54 35
7	44 52	49 33	13	34 56	55 37
8	3 54 20	50 31	14	4 41 48	56 40

A second comet was discovered by Dr. Bruhns at Berlin, on the 18th of March. Dr. Bruhns and Dr. Forster found as its position—

Berlin M.T.	R.A.	N.P.D.
March $18^d\ 8^h\ 28^m\ 30^s·6$	30° 49′ 54″·3	81° 40′ 30″·0

Both this and the comet of D'Arrest were comparatively bright at the time of discovery. No English observations have yet reached the Editor, from the unfavourable state of the weather the last week.

Dr. Bruhns has computed elements from Berlin observations on March 18, 19, and 20; which, as Mr. Pape has pointed out, bear a general resemblance to those of the third comet of 1846, as calculated by Dr. Van Galen for the present year.

Comet II. 1857. Dr. Bruhns.			Comet III. 1846. Dr. Van Galen.		
T	March 24·9877	B.M.T.	T	1857, June 25·77224	G.M.T.
π	119 36 34·3	App. Eq.	π	115 35 11·93	M. Eq.
Ω	116 10 50·4		Ω	101 54 2·67	June 25.
i	24 8 23·5		*i*	30 6 37·28	
Log. *q*	9·759140		φ	53 35 31·93	
Motion direct.			*n*	627″·1483	
			Log. *a*	0·5017575	

The third comet of 1846 was expected to return to perihelion in November 1851, but though sought for on all available opportunities at Cambridge and elsewhere, was not re-discovered in that year. A second return was fixed, as above, by Dr. Van Galen, for the end of June in the present year. The Editor fears that the readers of the *Monthly Notices* must be content to suspend their opinion on the possibility of the two orbits above given being reconcileable, until the new comet has been sufficiently observed for the computer to ascertain whether its elements are also elliptic. Not many days will be required for this purpose.

Mr. Bruhns has calculated the following Ephemeris for Berlin midnight from his parabolic elements :—

	R.A.	N.P.D.		R.A.	N.P.D.
	h m s	° ′		h m s	° ′
April 3	3 0 26	62 11	April 9	3 25 16	52 59
4	4 17	60 44	10	30 0	51 22
5	8 13	59 14	11	34 59	49 42
6	12 15	57 43	12	40 15	48 2
7	16 25	56 10	13	45 50	46 20
8	3 20 45	54 36	14	3 51 45	44 37

The comet will be visible throughout the month of May.

ERRATA.

Vol. XVI. No. 6, page 155, *Thetis*, 1856, March 11, M.S.T. of Observation, *for* $14^h 22^m 35^s{\cdot}4$, *read* $14^h 22^m 45^s{\cdot}4$; Apparent R.A., *for* $13^h 42^m 16^s{\cdot}29$, *read* $13^h 42^m 26^s{\cdot}29$.

Vol. XVII. page 36, line 11, *for* weight of tube, *read* weight of tube per square foot.

CONTENTS.

	Page
Fellows elected	135
Observations of small Planets at the Royal Observatory	ib.
Occultation of *Jupiter*. Professor Challis and Mr. Breen	136
Rev. W. R. Dawes, on two Occultations	141
Mr. Hippisley. Experimental Illustration of Projection	142
Mr. Lassell and the Astronomer Royal on same subject	ib.
Rev. Baden Powell. On Optical Phenomena in Occultations	143
G. C. Bompas, Esq. On the Horary Variation of Meteors	147
Extract of a Letter from Professor Argelander	148
Hansen. Supplement to Solar Tables	150
Dr. De Gasparis. Numerical Solution of Kepler's Problem	155
M. Babinet. An Expeditious Method of Finding the Latitude	158
Astronomer Royal. Support of Mercury-vessel for the Zenith-Sector ...	159
Two New Comets	161

London :—Printed by G. Barclay, Castle St. Leicester Sq. and Published at the Apartments of the Society, April 7, 1857.

R. A. S. Monthly Notices.

Appendix to No. 5, Vol. XVII.

The receipt of No. 1076 of the *Astronomische Nachrichten* enables the Editor to supply the additional and interesting intelligence that the comet of Dr. Bruhns proves to be identical with that of Brorsen, as suspected by Mr. Pape. An independent computation of approximate elliptic elements from observations made on March 18, 20, and 24, led at once to the adoption of a considerable angle of eccentricity, and justified Mr. Pape in assuming that a modification of the elements of Van Galen of admissible (though of unexpected) amount would suffice for the representation of the observations of the present year. He has thus found—

$$T = \text{March } 29{\cdot}22503 \text{ Berlin M.T.}$$
$$\left.\begin{aligned} \pi &= 115\ 52\ 15{\cdot}6 \\ \Omega &= 101\ 59\ 30{\cdot}8 \end{aligned}\right\} \text{M. Eq. } 1857{\cdot}0$$
$$i = 29\ 42\ 46{\cdot}7$$
$$\varphi = 53\ 21\ 0{\cdot}0$$
$$\text{Log } a = 0{\cdot}496045$$

from which he has computed the following short Ephemeris for immediate use :—

For Berlin Midnight.

1857	R.A. h m s	N.P.D. ° ′	1857	R.A. h m s	N.P.D. ° ′
April 1	2 54 38	66 4·1	April 9	3 24 54	56 16·9
2	2 58 2	64 53·8	10	3 29 23	55 0·7
3	3 1 32	63 42·5	11	3 34 7	53 44·2
4	3 5 8	62 30·4	12	3 39 9	52 27·4
5	3 8 50	61 17·3	13	3 44 29	51 10·2
6	3 12 38	60 3·4	14	3 50 9	49 52·8
7	3 16 34	58 48·6	15	3 56 9	48 35·3
8	3 20 38	57 33·1	16	4 2 29	47 17·7

A more extended Ephemeris will be supplied shortly.

R. C. C.